INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

A MANET Architecture Model

Thomas Heide Clausen

N° 6145

January 2007

Thème COM

Rapport de recherche

ISSN 0249-6399 ISRN INRIA/RR--6145--FR+ENG

A MANET Architecture Model

Thomas Heide Clausen

Thème COM — Systèmes communicants
Projets Hipercom

Rapport de recherche n° 6145 — January 2007 — 25 pages

Abstract: This memorandum describes a common misperception concerning MANETs and their underlying network architecture when integrating into classic IP networks. It details the consequences of this misperception – breaking compatibility with existing applications and protocols – and offers an architectural model for MANETs, which integrates MANETs into the IP networking architecture and encapsulates the MANET specific behavior in a way transparent to existing applications and protocols. Finally, this memorandum shows how the presented MANET architectural model fits with MANET deployment scenarios, including "simple MANETs" and management of nested NEMO networks.

Key-words: mobile network, ad hoc network, network architecture, address configuration, routing, IP networks, NEMO, MANET

Unité de recherche INRIA Futurs
Parc Club Orsay Université, ZAC des Vignes,
4, rue Jacques Monod, 91893 ORSAY Cedex (France)
Téléphone : +33 1 72 92 59 00 — Télécopie : +33 1 60 19 66 08

A MANET Architecture Model

Résumé : Ce mémorandum documente une erreur de perception répandue concernant les réseaux MANET et leur architecture réseau sous-jacente, lorsqu'ils sont integrés à des réseaux IP classiques. Il décrit les conséquences de cette erreur de perception – l'incompatibilité avec les protocoles et applications préexistants – et propose un modèle d'architecture pour ces reseaux MANETs, qui les intègre à l'architecture des réseaux IP et encapsule la partie du comportement qui est spécifique aux MANETs, de sorte qu'il paraissent transparent aux applications et aux protocoles existants. Enfin, ce mémorandum montre comment le modele architectural de MANET convient aux scenarii de deploiement des MANETs, en particulier les MANETs simples, et aussi a la gestion des reseaux NEMO integres.

Mots-clés : réseaux mobiles, réseaux ad-hoc, architecture de réseau, configuration d'adresses, protocole de routage, réseaux IP, NEMO, MANET

1 Introduction & Background

A typical text on Mobile Ad hoc NETworks (MANETS) will describe such networks as simply being *"a collection of mobile nodes, communicating among themselves over wireless links and thereby forming a dynamic, arbitrary graph"* – listing wireless characteristics and graph dynamics as the main challenges for designing protocols and applications for this network.

While capturing important characteristics, this description does not make explicit how MANETs map into the Internet architecture – and does therefore not allow evaluation of existing IP protocols and their applicability on MANETs. Similarly, the lack of a clear architectural description within the context of the Internet has impeded the evaluation of the applicability of MANETs within the Internet.

This fact became explicit during the chartering of the IETF AUTOCONF working group [8]: in simple terms, the goal of the AUTOCONF working group is to provide automatic address configuration for MANET nodes. Most researchers and engineers familiar with MANETs shared the understanding that existing autoconfiguration approaches did not apply. Describing why and how was, absent a clear and agreed upon architectural model of MANETs, difficult – as was communication to experts outside the MANET community.

The issue arose again within the context of routing and route optimisation within nested NEMO networks, where a clear architectural description of MANETs lead to a poor general understanding of how MANETs might be a candidate technology.

The purpose of this memorandum is to document the MANET architecture within the general Internet and IP architecture.

1.1 Memorandum Outline

The remainder of this memorandum are organised as follows: section 2 provides an overview of the classic IP link and network model, in particular the assumptions made by IP regarding subnets and links. Section 3 then elaborates important characteristics regarding MANET interfaces, comparing and contrasting with the IP assumptions of section 2. This is followed by section 4, in which a common misperception of the MANET architecture is elaborated, and where the shortcomings of this architectural misperception are presented.

Section 5 presents a MANET architectural model which integrates MANETs as a natural part of the Internet and the IP architecture – fitting the MANET characteristics (section 3) to the classic IP link and network model (section 2). Section 6 summarise the characteristics of the MANET architecture model. Given this architectural model for MANETs, section 7 describes the morphology of MANETs, in particular how one would use the model for configuring a "classic" MANET which respects the IP architecture. Section 8 discusses how MANETs can be employed as a component in the case of managing nested NEMO networks.

2 Classic IP Link and Network Model

As pointed out by [4], network protocols and applications are designed with specific assumptions of the nature of an IP link.

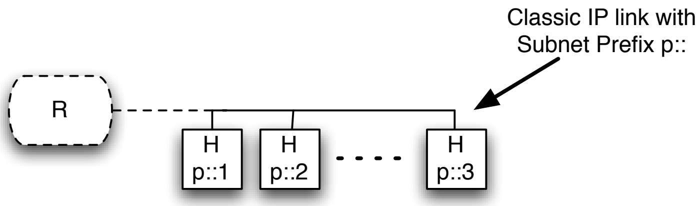

Figure 1: **Classic IP Link Model:** hosts (H) connected to the same link have assigned IP addresses from a common prefix, possibly assigned by a router (R).

Considering figure 1, these assumptions can be summarized as follows:

- all hosts (H) with network interfaces configured with addresses from within the same prefix `p::`, and with the same prefix `p::` assigned to the interfaces, can communicate directly with one another – *i.e.*:
  - IP datagrams are not forwarded at the network layer when communicating between interfaces which are configured with addresses from within the same prefix; hence
  - TTL/hop-limit in IP datagrams are not decremented when communicating between interfaces which are configured with addresses from within the same prefix, and;
  - IP datagrams with a TTL/hop-limit of 1 are (modulo data loss) delivered to all interfaces within the same subnet.
- link-local multicasts and broadcasts are received by all interfaces configured with addresses from within the same prefix without forwarding.

An even shorter summary of the *"classic IP link model"* is to say that "an IP link looks like an Ethernet".

It follows from the above that the notion of "IP link" is tied with the notion of an "IP Subnet" (IPv4) or a prefix (IPv6), in that all interfaces which are configured with the same subnet address or prefix are considered to be on the same IP link and thus that for communication between nodes on the same subnet, no forwarding is required and no decrement of TTL/hop-limit is performed.

Interfaces within the same prefix or, for IPv4, within the same subnet, are within the classic IP link model assumed to also be attached to the same classic IP link as described above. For completeness, it should be mentioned that the inverse is not necessarily true: in some network configurations, interfaces connected to the same classic IP link may be configured within different prefixes or subnets.

3 MANET Interface Characteristics

MANET nodes are equipped with MANET interfaces, which have different characteristics than the interfaces described for the classic IP Link and Network Model in section 2. These characteristics are briefly summarised in this section, with the purpose of exemplifying the difference with "Ethernet-like" interfaces. A MANET version of figure 1 looks as in figure 3.

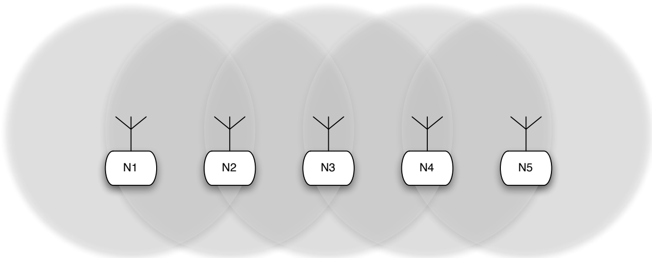

Figure 2: **MANET:** nodes (N) with MANET interfaces. The light grey area indicates the **coverage area** of each MANET interface.

3.1 Semi Broadcast Interfaces

Each MANET interface is a broadcast interface, typically, but not necessarily, wireless, which is able to establish a direct L2 connection with only those nodes which are within its coverage area. In figure 3, this coverage area is approximated by a simple disc of fixed radius – in the real world, both the shape and size of the coverage area is variable as a function of the interface, interference from the environment etc. Referring to figure 3 if, for example, if N3 transmits, then this transmission may be received by N2 and N4, but not by N1 and N5. This implies that, *e.g.*, N3 and N4 – despite being neighbours and on the same "link" – do not share the same view of which other nodes are neighbours and on the same "link": N3 considers that it is on the same "link" as N2 and N4, whereas N4 considers itself to be on the same "link" as N3 and N5.

This sometimes leads to describing MANET interfaces as **"semi-broadcast interfaces"**, with **non-transitive neighbour relationships**: neighbouring nodes may experience distinctly different neighbourhoods.

3.2 Shared Bandwidth

Depending on the radio technology used, MANET interfaces may interfere with each other – this is for example the case with the commonly used IEEE 802.11 interfaces. In figure 3, if N3 transmits over its MANET interface, then this may cause N2 and N4 to be unable to transmit concurrently over their respective MANET interfaces. The direct consequence hereof is, that available bandwidth is shared among the MANET interfaces within the same coverage area.

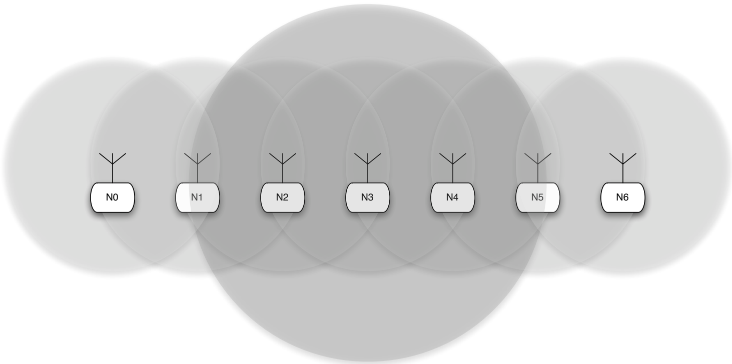

Figure 3: **MANET:** nodes (N) with MANET interfaces. The light grey area indicates the **coverage area** of each MANET interface. The dark grey circle indicates the **interference area** of the MANET interface of N3.

A further consideration is, that a wireless interface has an **"interference area"** which may be greater than its coverage area, *i.e.* a transmission by N3 in figure 3 will, as indicated above, be correctly received by the interfaces N2 and N4. At the same time, however, this transmission may be propagating to interfaces of N1 and N5 where, while the transmission can not be correctly decoded, it can be detected, and cause interference with other transmissions which could otherwise be correctly received over the MANET interfaces of N1 and N5 (such as transmissions from N0 and N6).

3.3 Hidden Terminals

A property of MANETs which is commonly brought forward is the **"hidden terminal problem"**: if N3 through some protocol agrees with its neighbours (N2 and N4) that it will, for the moment, have exclusive access to the wireless media via its MANET interface, then N3 may go ahead and make a transmission. However, if at the same time N1 also transmits over its MANET interface, then the transmissions of the MANET interfaces of N1 and N3 may appear concurrently at the MANET interface of N2 – potentially interfering and causing N2 to receive neither of the transmissions. Denoted a "collision", the possibility and probability of this occurring depends on the L2 (data link layer) mechanisms in place – suffice to observe that the such collisions can and do occur when using some common wireless interfaces such as IEEE 802.11.

The term "hidden terminal" originates from the fact that while the node wishing exclusive access to the wireless media may negotiate this with its direct neighbours (in our case N2 and N4), whereas nodes out of direct radio range (in our case N1 and N5) are "hidden".

3.4 Asymmetric Connectivity

Considering figure 1, an axiomatic assumption is that neighbour relationships are symmetric: if communication from one interface to another interface is possible in one hop, then communication in the inverse direction is also possible – in other words, connectivity between neighbour interfaces is symmetric. Considering the small MANET in figure 4: for some reason (powerful transmitter, large antenna, ...) the MANET interface of N1 has a large enough coverage area that its transmissions can be received by the MANET interface N2. The MANET interface of N2, on the other hand, has a much smaller coverage radius, such that transmissions from the MANET interface of N2 do not arrive at the MANET interface of N1. Thus an asymmetric – or more precisely, an unidirectional – connectivity between the MANET interface of N1 and the MANET interface of N2 exists: N2 sees N1 as a neighbour (since the MANET interface N2 can receive transmissions from the MANET interface of N1), whereas N1 does not see N2 as a neighbour (since the MANET interface of N1 can not receive transmissions from the MANET interface of N2). Thus, MANET neighbour relationships are **non-reflective**.

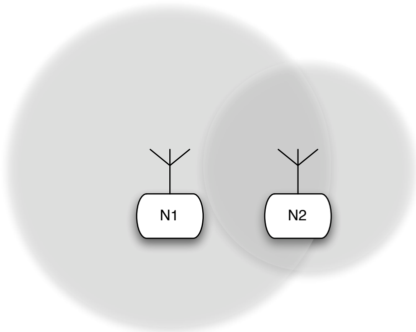

Figure 4: **MANET:** neighbour asymmetry.

3.5 Neighbourhood & Network Membership

Returning to the initial description of a MANET in the introduction, MANET interfaces form, *"a dynamic, arbitrary graph"* among themselves. This indicates that the neighbourhood of a MANET interface is dynamic and varies over time – either due to node mobility or due to environmental factors which impact the area of coverage of a MANET interface. On a larger scale even the MANET membership may be time varying, with MANET interfaces appearing and disappearing over time, and for the same reasons.

4 Common MANET Misperception

Considering the classic IP link model described in section 2, a common misperception is that "a MANET should emulate an Ethernet at L3", and that the nodes in a MANET are "hosts". This has lead to MANET nodes being perceived and configured as indicated in figure 5 as hosts in an Ethernet: the MANET interface is assigned an IP address and a subnet prefix `p::` – a prefix which is shared among all the nodes in the MANET as indicated in figure 6.

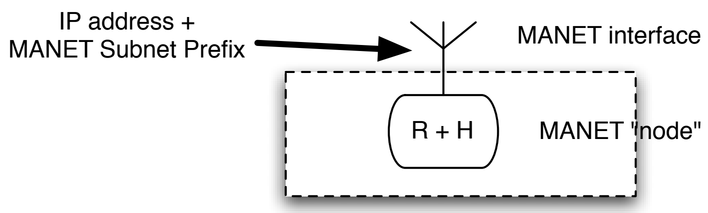

Figure 5: **Common Misperception of MANET Nodes:** viewing MANET nodes as regular hosts in a subnet, with an IP address and a subnet prefix assigned to their MANET interface.

Configuring a MANET with a single subnet prefix shared among the MANET nodes implies that all MANET nodes would be considered as belonging to the same subnet – and as such on the same IP link. However with the MANET forming a multi-hop L3 network, and given the characteristics outlined in section 3 the protocol and application assumptions for IP links listed in section 2 do not hold:

- for interfaces within the MANET and with the same prefix to communicate, L3 forwarding of IP datagrams may occur, and with such forwarding, TTL/hop-limit are decremented;
- link-local multicast or broadcasts either do not reach all nodes within the subnet – or if they are to reach all nodes within the subnet, they are to be forwarded by intermediate nodes

In short, considering and configuring MANET nodes as if the MANET forms a single subnet breaks the classic IP link model and the applications which assume the characteristics of the classic IP link model. [4] explores this in more detail.

4.1 Routing Incompatibility

A perhaps surprising example of an application, which breaks under this common MANET misperception, is routing: if a multi-hop MANET is configured as described in this section,

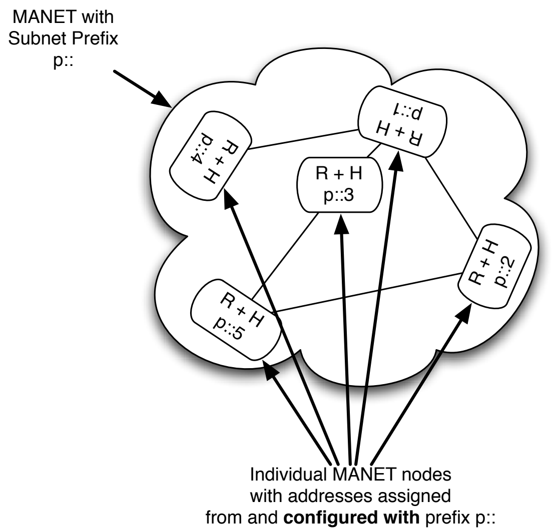

Figure 6: **Common misperception of a MANET:** viewing the MANET as a classic IP subnet as in figure 1 such that all nodes participate in the same "subnet", and thus share the same subnet prefix.

with all nodes within the MANET assumed to be also in the same subnet, then forwarding of IP datagrams within the MANET will prompt intermediate nodes to produce ICMP redirects. This is appropriate since IP datagrams delivered within a subnet are not supposed to be forwarded by a router since a direct link between any two nodes within a subnet is supposed to exist, according to the classic IP link model described in section 2.

A rough work-around, often proposed in order to "mask" this problem, is to disable ICMP redirect.

4.2 Incompatibility with Other Protocols and Applications?

Disabling ICMP redirects to make routing operate is disabling the symptom of an incorrect network model, for a single application (routing) only, and leads to the specific and reasonable question if other applications and protocols require similar tweaks (if so, which applications/protocols and which tweaks?). Even more general: one could ask if MANETs even do belong in the IP world? The answer is yes, MANETs do belong in the IP world – however it also means that the architectural view, presented in this section, is inappropriate and indeed a common misperception of MANETs, which does not take into consideration their integration within the IP architecture.

5 A MANET Architectural Model

This section presents an architectural model for MANETs which preserves the integrity of the IP architecture while allowing for the particularities of MANETs.

5.1 MANET Node Morphology

This architectural model considers MANET nodes as **routers** with hosts attached, as illustrated in figure 7. These attached hosts may be "external" (i.e. attached to the router via other network interfaces) or "internal" – however the important observation to make is, that the links between these hosts and the router are classic IP links, behaving as described in section 2. This implies that, from the point of view of the hosts, and the applications running on these hosts, connectivity is via a classic IP link. Hosts, and their applications, are not exposed to the specific characteristics of the MANET interfaces and are connected to the MANET via a router, which has one or more MANET interfaces. This is symmetric with how hosts on an Ethernet, such as illustrated in figure 1 are not exposed to the intricacies of what type of connectivity the router has beyond the Ethernet.

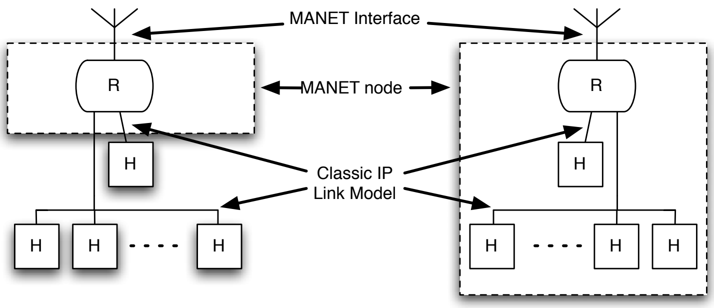

Figure 7: **MANET node model:** the router (R) has on the top a MANET interface, and is connected, on the bottom, to hosts (H) via classic IP links.

Since the hosts in figure 7 are connected to a classic IP link, these hosts are configured and behave as hosts in any other network, and the links to which they are connected have properties identical to those of any other classic IP link.

5.2 Addresses and Prefixes

If the MANET router is delegated a prefix `p::`, this prefix can be assigned to the classic IP link(s), and hosts can be assigned addresses from within this prefix, and configured with this prefix as illustrated in figure 8. Specifically, the MANET interface(s) of the router are **not** configured **with** this prefix, for the reasons explained in section 4: the MANET interface(s) is not on the same "link" as the other interfaces with addresses from within this prefix, and so direct communication without crossing a router is not possible. The configuration of MANET interfaces is detailed below.

5.3 MANET Interface Configuration & Properties

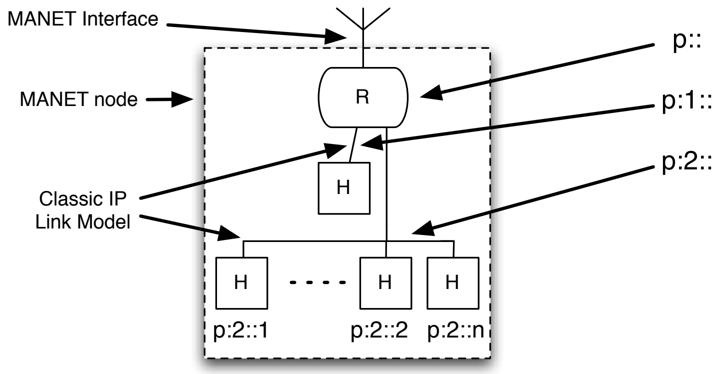

Figure 8: **MANET node and prefixes:** the MANET router (R) is delegated a prefix `p::`, which it assigns to the classic IP links to which the hosts (H) are attached.

MANET specific behaviors are exclusively exposed to the MANET interface(s) of the routers. This includes MANET routing protocols and interface and link characteristics (asymmetric neighbourhoods, semi-broadcast interfaces, fuzzy neighbor relationships, topology dynamics etc.) The following characteristics deserve particular mention, since they distinguish MANET interfaces and the MANET link model from the classic IP link model:

Unique Prefixes

MANET interfaces must be configured with unique prefixes, i.e. such that no two MANET interfaces are configured such that they appear within the same IP subnet. Some common ways to achieve this are:

- unnumbered interfaces (IPv4) [1];
- Link-Local Addresses (IPv6);
- /128 (IPv6) or /32 (IPv4) prefixes.

However it is worth noting that prefix lengths shorter than /128 (IPv6) or /32 (IPv4) are possible on the MANET interface, so long as the prefixes are unique to a single MANET interface.

Link Local Mulitcast/broadcast Scope
On a MANET interface, a Link Local multicast or broadcasts reach MANET interfaces of neighbor nodes only, regardless of their configured addresses. A Link Local multicast or broadcast on a MANET interface is, thus, a "neighborcast", and is not forwarded nor assumed to be received by all nodes within a MANET.

5.4 MANET Network View

Following the architecture described in the above, a configured MANET with routers and hosts, looks as in figure 9: the inner white cloud represents where MANET interfaces and links form a MANET – and the outer gray cloud represents where the classic IP link model as described in section 2 is assumed.

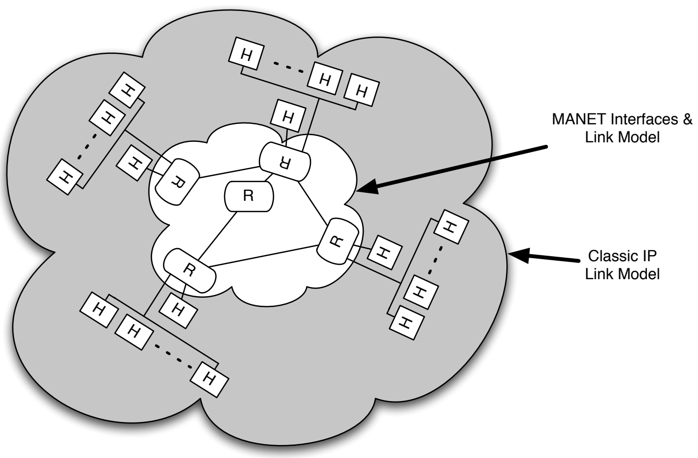

Figure 9: **MANET Network Model:** the inner white cloud is where MANET interfaces and links for a MANET are found and MANET specific protocols apply. The outer gray cloud represents where the classic IP link model (and regular applications/protocols) applies.

6 Properties of Proposed Architectural Model

The MANET architecture model presented in this memorandum makes a clear separation between the roles of router and host in a MANET, recognizing that:

- MANET interfaces are seen only by the router, assumed to be MANET aware and running appropriate protocols and applications;
- MANET interfaces forming a multi-hop MANET area may use a site (not subnet) prefix (aggregation, ...);
- hosts/subnets on non-MANET interfaces assume a classic IP link model;
- applications on hosts see classic IP interfaces connected to a classic IP link, and therefore;
- applications on hosts and protocols assuming classic IP interfaces can run unmodified.

Refering to figure 9, the scope of MANET specific protocols is, thus, the inner white cloud. This thus scopes routing protocols such as those developed by the IETF MANET working group [7] and autoconfiguration protocols developed by the IETF AUTOCONF working group [8] to routing and configuring MANET interfaces on MANET routers.

7 MANET Configurations

The MANET architectural model outlined in section 5 does not conflict how MANETs have been perceived and deployed. Rather, it gives a way of thinking about MANETs corresponding to the IP architecture.

This section will exemplify how "common" MANET deployments fit with this architectural model. Notice that this section contains examples which correspond to the architectural model, but does not attempt to exhaustively enumerate all possible deployments or scenario nor to capture all possible requirements to MANETs.

7.1 A MANET with a Single Internal Host

A source for the misperception in section 4 is a common configuration of MANET nodes, where each node has one MANET interface and one internal host, as in figure 10.

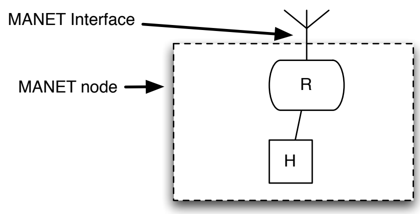

Figure 10: **A Simple MANET Node:** one MANET interface and one internal host (H).

For this example, addresses within the MANET are extracted from a single common MANET prefix – *e.g.* 192.168.0.0/16. The interface of the host must be configured, and see a classic IP link as described in section 2. The interface of this host is the only interface on the link (other than that of the router), and can be assigned an IP address of the form 192.168.1.1/32 to, as in figure 11.

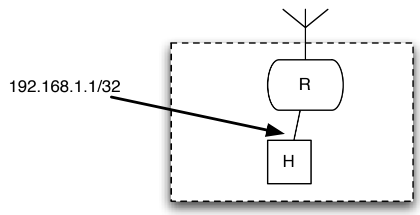

Figure 11: **A Simple MANET Node:** one MANET interface and one internal host (H), with the interface of the host configured with an IP address and an "all-ones" netmask.

This corresponds to the router having been delegated the prefix 192.168.1.1/32 – IP addresses from within that prefix are then distributed to hosts connected over a classic IP link.

The MANET interface must be configured according to the requirements in section 5. One way of satisfying the requirements set forth in that section is through assigning the same address/prefix to the MANET interface as to the internal host. Traffic to the router will typically be addressed to a well-known multicast address, thus the router can distinguish between traffic to itself and traffic to the host – similar to unnumbered interfaces.

A common misperception is to consider all MANET nodes as belonging to the same subnet (192.168.0.0/16) and configuring each MANET interface with an address/prefix such as 192.168.0.0/16, as in figure 12 (b). This is **wrong**, as described in section 4.

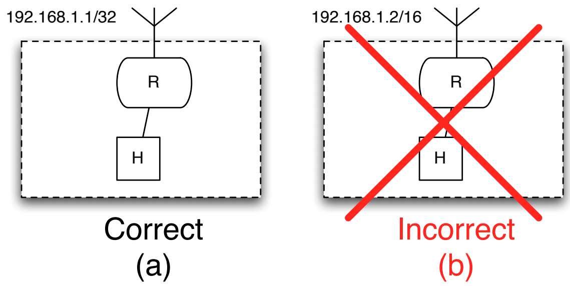

Figure 12: **Simple MANET Nodes:** addresses assigned from the 192.168.0.0/16 prefix. Left: correct configuration wrt. the architectural model (section 5). Right: incorrect configuration, leading to the "common MANET misperception".

Figure 13 illustrates a cloud of simple MANET nodes, each correctly configured with IPv4 address and a /32 prefix length on their MANET interfaces.

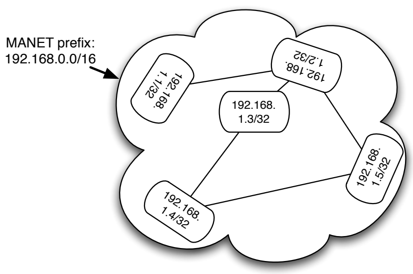

Figure 13: **Simple MANET:** addresses assigned from, 192.168.0.0/16, each MANET interface configured with a /32.

7.2 A MANET with Attached Hosts

In this case, a MANET node consists of a router and a set of hosts, attached to the router via a classic IP link. As in the previous example, the MANET interface, and the interfaces on the classic IP link are to be configured with addresses/prefixes from MANET prefix of 192.168.0.0/16.

Each MANET router is delegated a prefix, e.g. 192.168.1.0/24, which is assigned to the classic IP link. The interfaces (of hosts and of the router) connected to that link are configured, using any standard mechanism such as [2], with an IP address from that prefix and a /24 prefix. Again, the hosts are exposed to a classic IP link, retaining compatibility with existing applications and protocols.

The MANET interface is configured as an unnumbered interface, with a prefix length of /32, borrowing the IP address from the other (non-MANET) interface of the router. This is illustrated in figure 14.

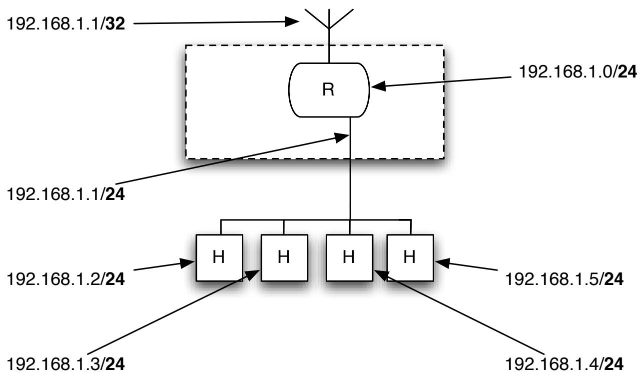

Figure 14: **MANET Node with Multiple Hosts:** one MANET interface and multiple attached hosts (H).

8 Nested Mobile Networks

The NEMO basic support specification [3] describes how a **mobile network** – a **mobile router** with attached hosts – can change its **point of attachment** to the Internet, employing MobileIP-like mechanisms to remain reachable: a **care-of-prefix**[1] is acquired at the current point of attachment, signalled to a **home agent**, and used by the home agent to **tunnel** traffic destined for hosts in the mobile network to this new point of attachment.

A mobile router may attach to any router, including another mobile router, forming networks of mobile routers to an arbitrary depth, and may change their point of attachment at any given time. Commonly, the terms **"nested mobile network"** or **"nested NEMO"** are used for this situation. A nested mobile network, thus, looks as illustrated in figure 15.

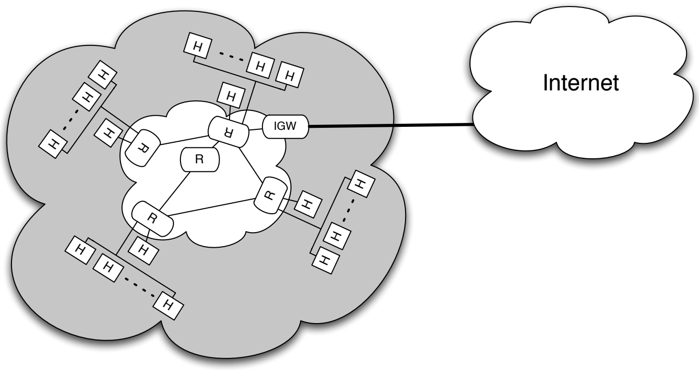

Figure 15: **Nested Mobile Network:** mobile routers (R) with attached hosts (H) connected to the Internet via an Internet Gateway (IGW).

8.1 Issues & Tasks

[3] does not stipulate how nested mobile networks are structured or managed, which entails that sub-optimal paths and loops can occur [5], [6]. Alleviating these, each mobile router (MR) must:

- maintain loop-free paths to Internet Gateway(s) (IGW); IGWs must maintain loop-free paths to the MRs;
- select (according to some metrics) one or more IGWs, from which it will acquire a care-of-prefix;

[1] Strictly speaking, NEMO requires that a **care-of address** be acquired, yet an address is a special instance of a prefix where the prefix length is equal to the address length. Since the nature of addresses and prefixes is otherwise the same, and since mechanisms for assigning/acquiring addresses are a subset of those assigning/acquiring prefixes, this memo will employ the term **care-of-prefix**.

- maintain loop-free paths to other MRs, whereby traffic between nodes within the nested mobile network can avoid crossing through the Internet.

8.2 Relationship to MANETs

MANET routers (see section 5 and mobile routers in a nested mobile network must, both:

- form time-varying connections with other MANET nodes / mobile routers;
- maintain loop-free paths to other MANET nodes / other mobile routers and IGWs;
- acquire prefixes in order to correctly configure interfaces and attached hosts.

MANET routing protocols are developed by [7], satisfying the first two of these items, thereby providing paths between MRs and IGWs and between MRs themselves.

The AUTOCONF activity [8] is chartered to develop solutions satisfying the third of the items above, including allowing MRs to acquire prefixes from an IGW. Specifically, to:

- provide MANET-wide unique prefixes to each MANET node / mobile router;
- if one or more IGW is present, provide unique global prefixes to each MANET node / mobile router;
- detect and resolve if non-unique prefixes are assigned to MANET nodes / mobile routers (*e.g.* as a result of a network partitioning/merger).

8.3 MANET Supported Route Optimisation in Nested Mobile Networks

Assuming a nested mobile network, where each MR has a home prefix, as in figure 16a. Each MR acquires a care-of-prefix from the IGW. This care-of-prefix is topologically correct with respect to the IGW, but not necessarily hierarchical within the nested mobile network, as in figure 16b.

MRs will perform binding updates to their home agents using the care-of-prefix as obtained from the IGW. Thus, the MR appears directly attached to the IGW, and nested redirects (as in figure 17a) for communication from the Internet are avoided. It is worth noting that this exactly as described in section 7.2, where each MANET node is assigned a unique prefix from within a MANET wide prefix.

- **By using a MANET routing protocol and an AUTOCONF [8] autoconfiguration mechanism, route optimisation for communication over the Internet is obtained.**

MRs will run a MANET routing protocol, which will advertise both their home prefix and the care-of-prefix. Hosts in the nested mobile network are, via their MRs, able to find paths between each other using their home addresses, without passing through the IGW and the Internet (as in figure 17b).

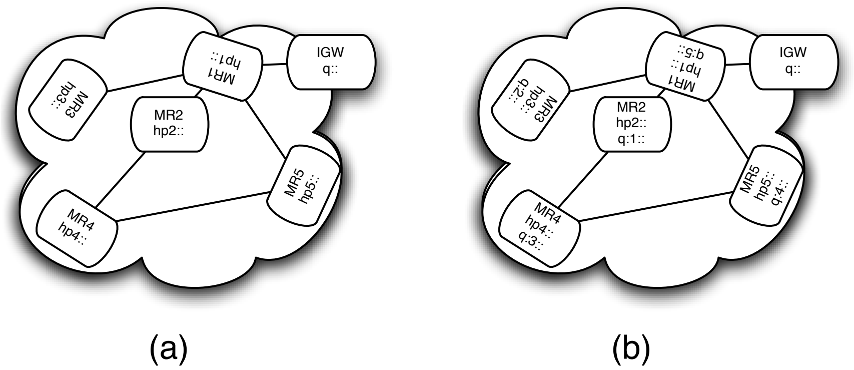

Figure 16: **Addresses in Nested Mobile Network:** (a) MRs with their home prefixes (hp1:: ...) and an IGW with global prefix (q::) (b) MRs with home prefixes(hp:: ...) and care-of-prefixes (q:1::, ...) assigned by the IGW.

- **By using a MANET routing protocol and an AUTOCONF [8] autoconfiguration mechanism, route optimisation for communication within the nested mobile network is obtained.**

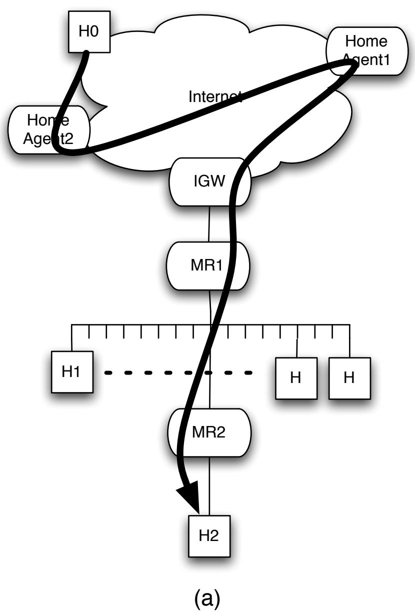

Figure 17: **Sub-optimal Routes in Mobile Networks:** (a) traffic from the Internet to a host not directly connected to the IGW is redirected via two home agents. (b) traffic from one host in the nested mobile network to another host in the nested mobile network is forced through the Internet.

9 Conclusion

This memorandum has described a coherent MANET architectural model, which conforms to the architectural model of the Internet. In particular, this model respects the addressing and prefix architecture of the Internet, preserves the usual semantics of a subnet as related to a link, and thereby preserves compatibility with classic applications and protocols running on hosts or between hosts and routers in the Internet. MANET specific issues are isolated to a MANET interface, and are therefore exposed only to protocols dedicated for managing MANETs. The architectural model describes the MANET specific issues, which must be taken into consideration when designing such protocols for MANET management.

Furthermore, this memorandum has shown how the architectural model is compatible with different MANET deployments and with other Internet protocols. In particular, this memorandum has shown how nested mobile networks are a typical example of a MANET, where MANET protocols solve problems such as route optimisation. This, both for communication between hosts on the internet and in the nested mobile network, and for communication between hosts within the nested mobile network.

Acknowledgements

The MANET architecture model presented is the result of exhaustive discussions with the participants in the IETF MANET and AUTOCONF working groups.

Special thanks to Dave Thaler (the author of [4], from which much of this discussion is derived) and Ian Chakeres for discussion and inspiration to the document in general and to section 3 in particular.

Thanks to Jari Akko, Thomas Nartan, Bob Hinden and Joe Macker for their significant contributions in formulating and refining this model. Also thanks to Christopher Dearlove, Allan Cullen, Andreas Enge, Ulrich Herberg, Philippe Jacquet, Cedric Adjih and Emmanuel Baccelli for their reviews and comments.

References

[1] F. Baker, "RFC1812: Requirements for IP Version 4 Routers", Standards Track, http://www.ietf.org/rfc/rfc1812.txt

[2] T. Narten, S. Thomson, "RFC2462: IPv6 Stateless Address Autoconfiguration", Standards Track, http://www.ietf.org/rfc/rfc2462.txt

[3] V. Devarapalli, R. Wakikawa, A. Petrescu, P. Thubert, "RFC3963: Network Mobility (NEMO) Basic Support Protocol", Standards Track, http://www.ietf.org/rfc/rfc3963.txt

[4] D. Thaler, "Multilink Subnet Issues", Internet-Draft (Work in Progress), http://www.ietf.org/internet-drafts/draft-iab-multilink-subnet-issues-02.txt

[5] T. Clausen, E. Baccelli, R. Wakikawa, "NEMO Route Optimisation Problem Statement", Internet-Draft (Work in Progress), http://www.ietf.org/draft-clausen-nemo-ro-problem-statement-01.txt

[6] T. Clausen, E. Baccelli, R. Wakikawa, "Route Optimisation in Nested Mobile Networks (NEMO) using OLSR", Proceedings of the IASTED International Conference on Networks and Communications Systems (NCS), April, 2005

[7] IETF MANET Working Group Charter, http://www.ietf.org/html.charters/manet-charter.html

[8] IETF AUTOCONF Working Group Charter, http://www.ietf.org/html.charters/autoconf-charter.html

Contents

Unité de recherche INRIA Futurs
Parc Club Orsay Université - ZAC des Vignes
4, rue Jacques Monod - 91893 ORSAY Cedex (France)

Unité de recherche INRIA Lorraine : LORIA, Technopôle de Nancy-Brabois - Campus scientifique
615, rue du Jardin Botanique - BP 101 - 54602 Villers-lès-Nancy Cedex (France)
Unité de recherche INRIA Rennes : IRISA, Campus universitaire de Beaulieu - 35042 Rennes Cedex (France)
Unité de recherche INRIA Rhône-Alpes : 655, avenue de l'Europe - 38334 Montbonnot Saint-Ismier (France)
Unité de recherche INRIA Rocquencourt : Domaine de Voluceau - Rocquencourt - BP 105 - 78153 Le Chesnay Cedex (France)
Unité de recherche INRIA Sophia Antipolis : 2004, route des Lucioles - BP 93 - 06902 Sophia Antipolis Cedex (France)

Éditeur
INRIA - Domaine de Voluceau - Rocquencourt, BP 105 - 78153 Le Chesnay Cedex (France)
http://www.inria.fr
ISSN 0249-6399